Development of AMSR-E Brightness Temperature Data Assimilation System on the JMA Global Analysis

Yoshiaki SATO

Numerical Prediction Division,

Japan Meteorological Agency

14 Sep. 2005, Joint AMSR Science team meeting

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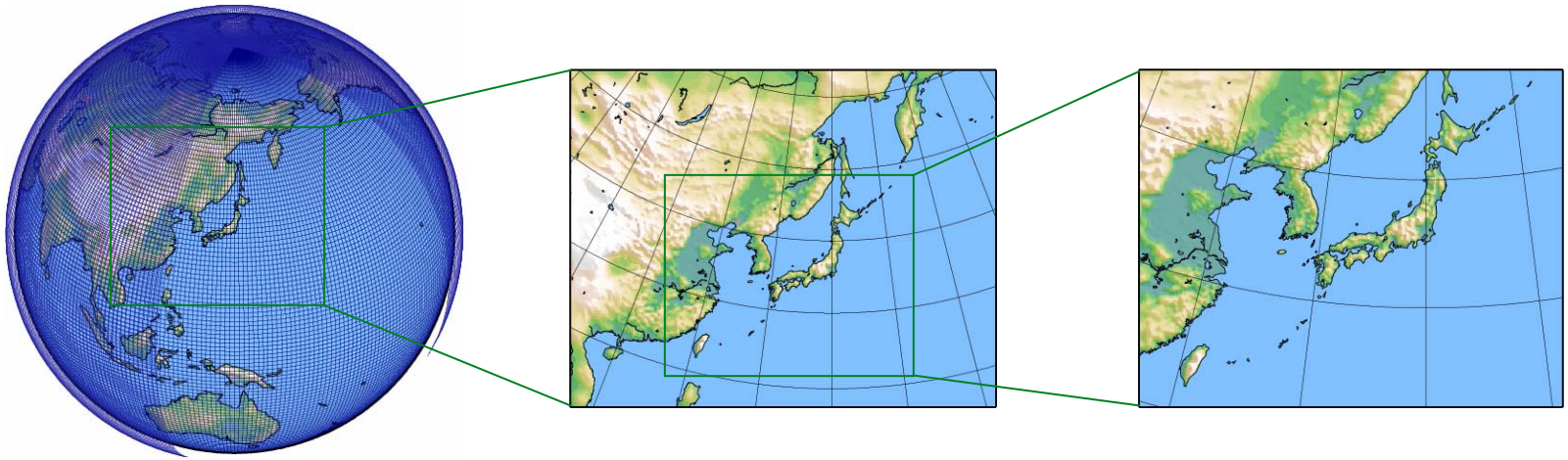
- Introduction
  - JMA Operational Models
  - AMSR-E Data assimilation
- GSM-4DVAR
- Experiment setting
- Experiment results
- Summary

JMA Operational NWP Models



Global Spectral Model

T_L319 (60km)
40 Layers (~0.4hPa)
（updated on Feb. 2005）
96/216hrs （00/12UTC)
for 1 week forecast

DA-System
4DVAR (T63)
（updated on Feb. 2005）

Regional Spectral Model

H.Rez.: 20km
40 Layers (~10hPa)

51hrs （00,12UTC）
for 2 days forecast

DA-System
4DVAR (40km)
(since Jun. 2003)

Meso-Scale Model

H.Rez.:10km
40 Layers (~22km)
（updated on Sep. 2004）
18hrs（00,06,12,18UTC）
for several hours forecast

DA-System
4DVAR (20km)
(since Mar. 2002)

Current Utilization of the AMSR-E

- Using MWR (including AMSR-E) data
  - on MSM (Meso-Scale Model)
    - Operationally Assimilated
      - as Total Column Precipitable Water (TCPW) & Rain Rate (RR)
        - » SSM/I&TMI from Oct. 2003
        - » AMSR-E from Nov. 2004
  - on RSM (Regional Spectral Model)
    - N/A
      - Because RSM will be replaced by high resolution GSM in some years
  - on GSM (Global Spectral Model)
    - Under Development
      - as TCPW
      - as Brightness Temperature (T_B) : Today's Topics !

Contents

- Introduction
- GSM-4DVAR
  - Configurations
  - Observations
- Experiment setting
- Experiment results
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DA system for GSM

- Upgraded from 3DVAR to 4DVAR on Feb. 2005
  - Configurations **> Flow Chart**
    - Incremental method
      - Outer Model : T_L319 (~60km) Non Liner models
      - Inner Model : T63 (~200km) NonLinear/ TangentLinear/ AdJoint models
    - 6-hour assimilation window, with hourly observation cost calculation
    - 35 (basic physics) + 35 (moist physics) iterations
  - Observations **> Distribution Sample**
    - Surface Observation, Upper Air Sounding,
      Aviation, Bogus, Atmospheric Motion Vectors, Scatterometer
      AMSU-A/B
      - assimilated as T_B with RTM (RTTOV7)
      - => We can upgrade the 4DVAR to use MWR-T_B

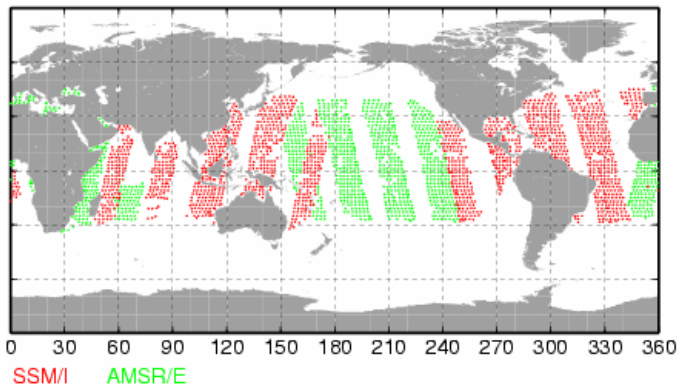
Contents

- Introduction
- GSM-4DVAR
- Experiment setting
  - OSE settings
  - Sample of the bias correction
- Experiment results
- Summary

Configuration of OSE on MWR-T_B Data

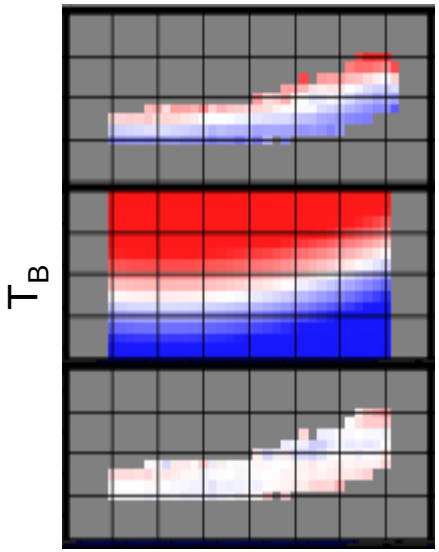
- Study Period:
  - Assimilation: 2004.07.20-09.10
  - Evaluation: 2004.08.01-08.31

- Spec. of MWR-T_B Data Assimilation
  - MWR-T_B data
    - SSM/I : 19V, 22V, 37V, 85V
    - AMSR-E: 18V, 23V, 36V, 89V
  - Observation Error Setting
    - (S.D. of the T_B departure from GSM) x 2
  - Area
    - Over the clear and thin cloudy ocean with SST >= 20deg.C
  - Bias Correction
    - With the parameters of SST^2, SST, Guess-T_B



Sample of the Bias Correction

AMSR-E T36V



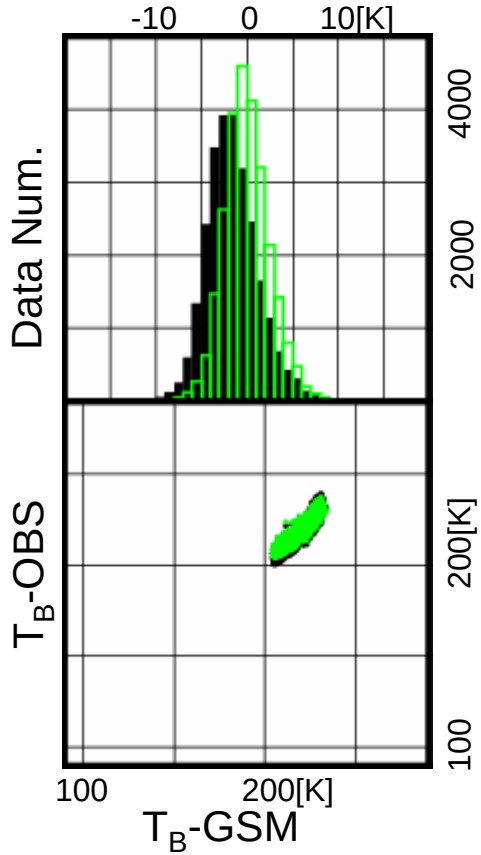
Color shows Mean Error from GSM
Blue <- 0 +> Red

ME depends on T_B and SST

$BC = A\ SST^2 + B\ SST + C\ T_B + D$

A, B, C, D : constants

< Mean Error >



Original / Bias Corrected

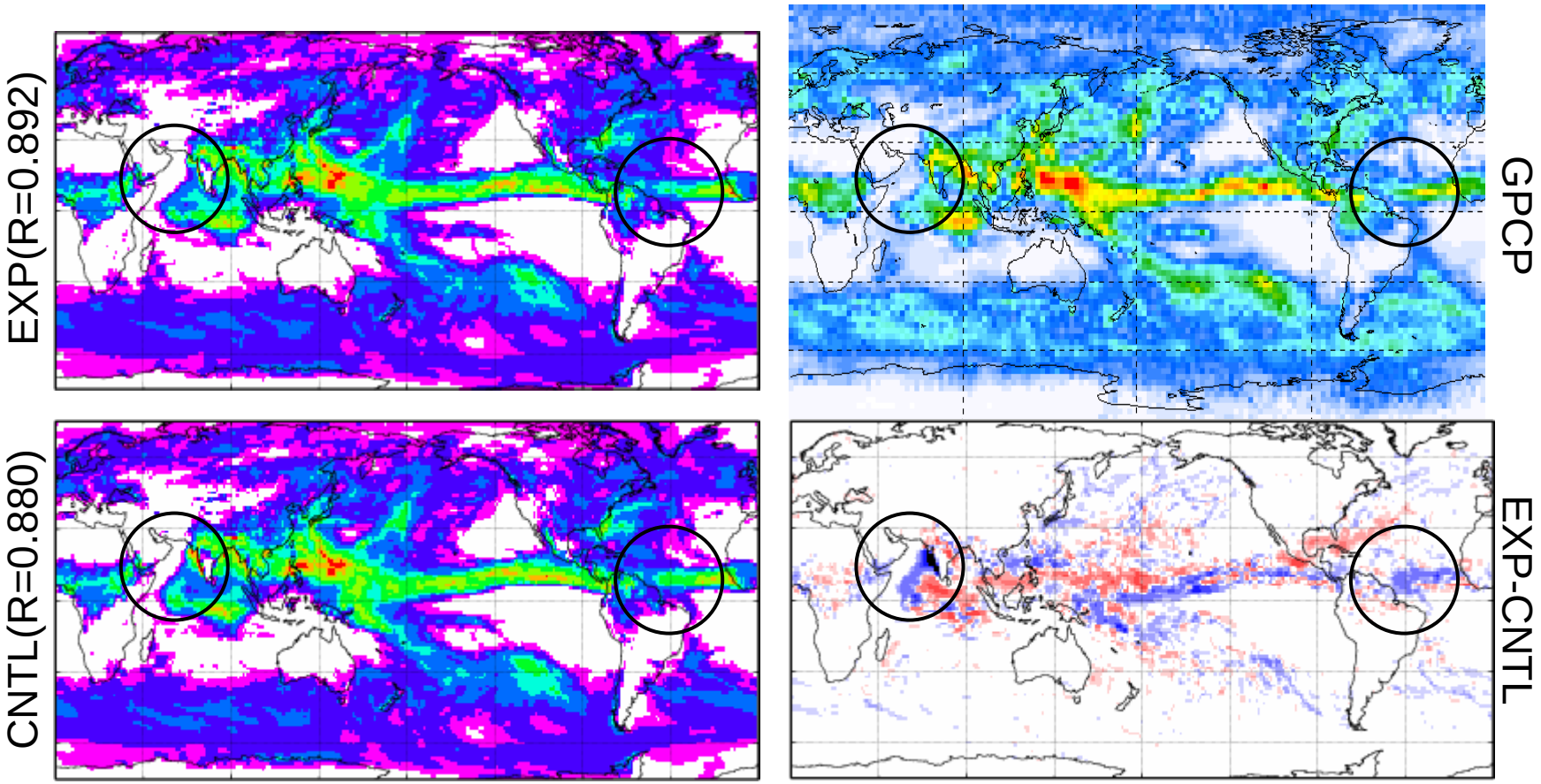
N=26230
R=0.944 ME=-1.578 RMSE=3.251
R=0.951 ME= 0.021 RMSE=2.479

Contents

- Introduction
- Configuration of the GSM-4DVAR
- Experiment setting
- Experiment results
  - Positive result
  - Negative result
  - Discussion
- Summary

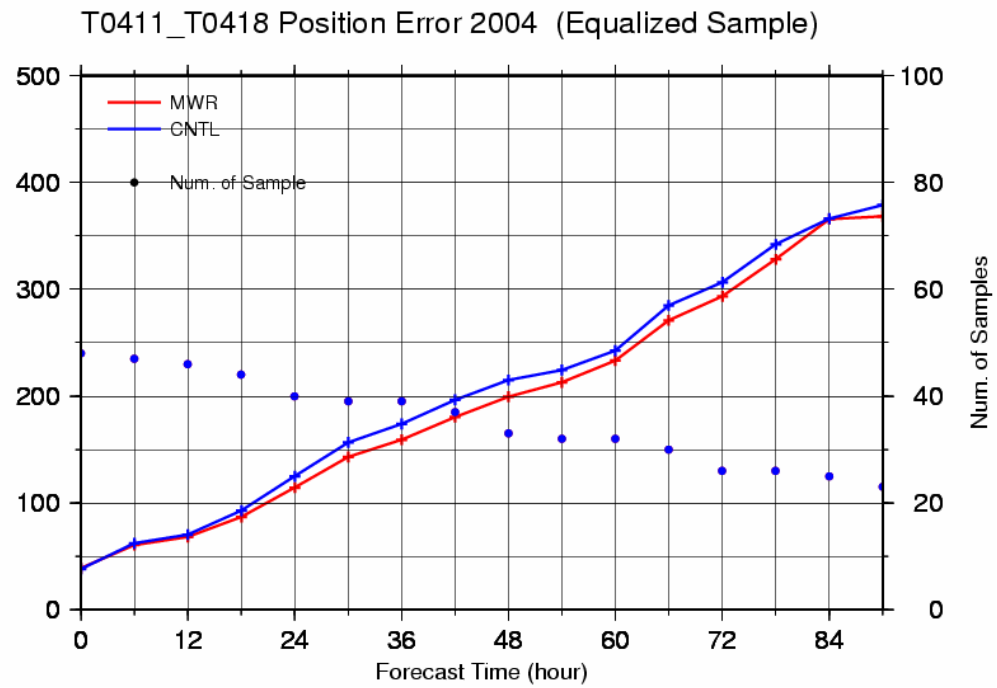
Improvement on monthly rainfall distribution

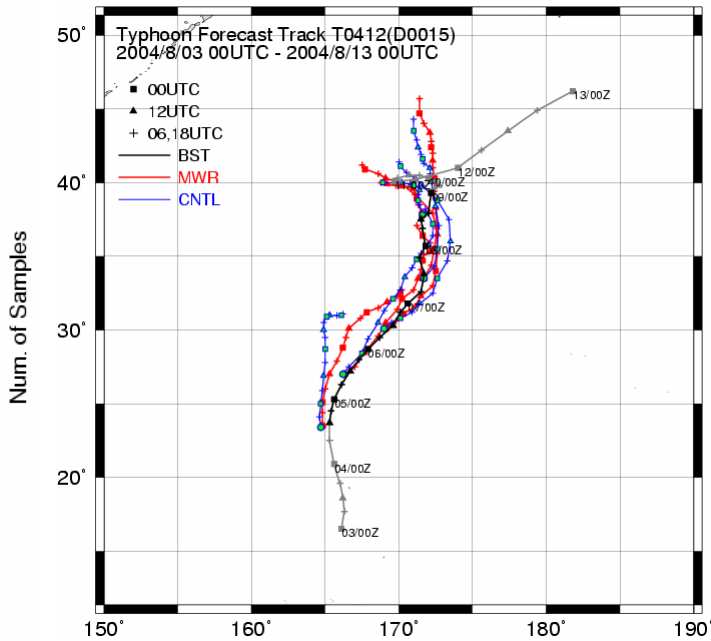
- Evaluated by the GPCP monthly rainfall data
  - Correlation is improved from 0.880 to 0.892



Improvement on Typhoon Track Forecast

- Evaluated by the “JMA Best Track” data
  - Typhoon position error become smaller



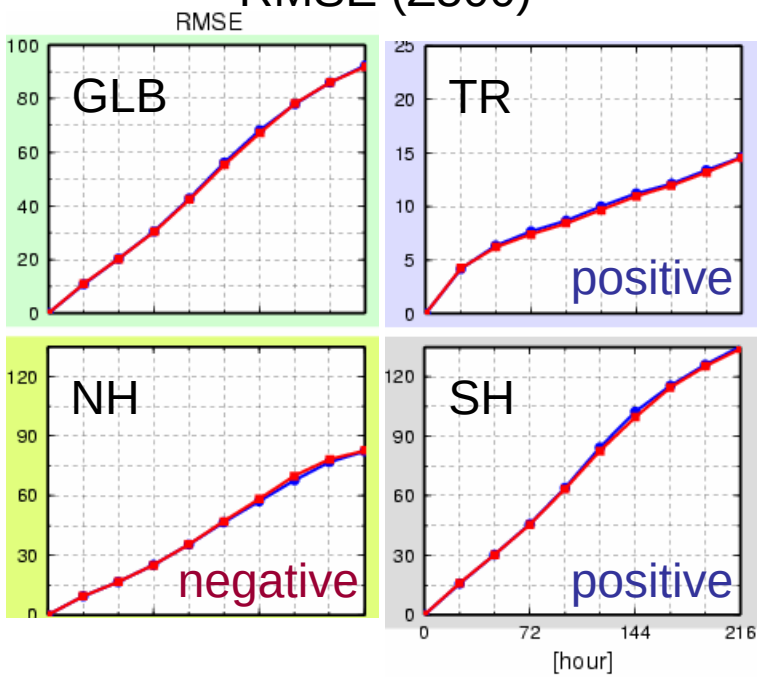


RMSE against Initial Conditions…

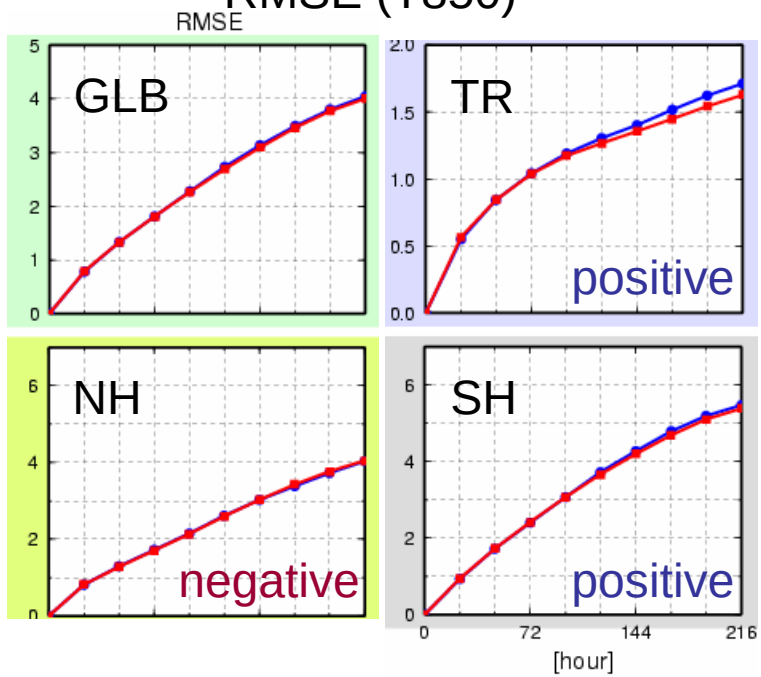
- RMSE sequence on Z500/T850 for 216hrs forecast
  - Positive : over the Tropics and S.H.
  - Negative : over the N.H.
    - Unfortunately Japan Islands are located in N.H.

      => operational use is not permitted

RMSE (Z500)



RMSE (T850)



Why?

- Why does MWR data make the N.H. prediction worse ?
  - Bias correction ?
    - We did some sensitivity tests (for other parameters)
      - No result showed the better score.
  - Data Coverage ?
    - We did some sensitivity tests (for SST limitation)
      - No result showed the better score.
  - Thinning Method ?
    - Only considered spatial distribution but temporal difference.
    - => new thinning method.
  - Inconsistency with Other satellite data ?
    - It needs to consider the AMSU-A/B T_B bias correction.
    - => “Variational Bias Correction (VBC)”
      - VBC was developed at NCEP
  - or… Hard Luck ?

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Summary

- MWR T_B DA system for GSM4DVAR was implemented.
- The result shows
  - Improvement on Rainfall distribution
  - Improvement on Typhoon Track Forecast
  - Improvement on T850 & Z500 forecast in the Tropics & S.H.
  - However the T850 & Z500 forecast was not improved in the N.H.

  $\Rightarrow$ Thus, the operational use of MWR T_B has not started yet.
    - The cause is still under investigation.

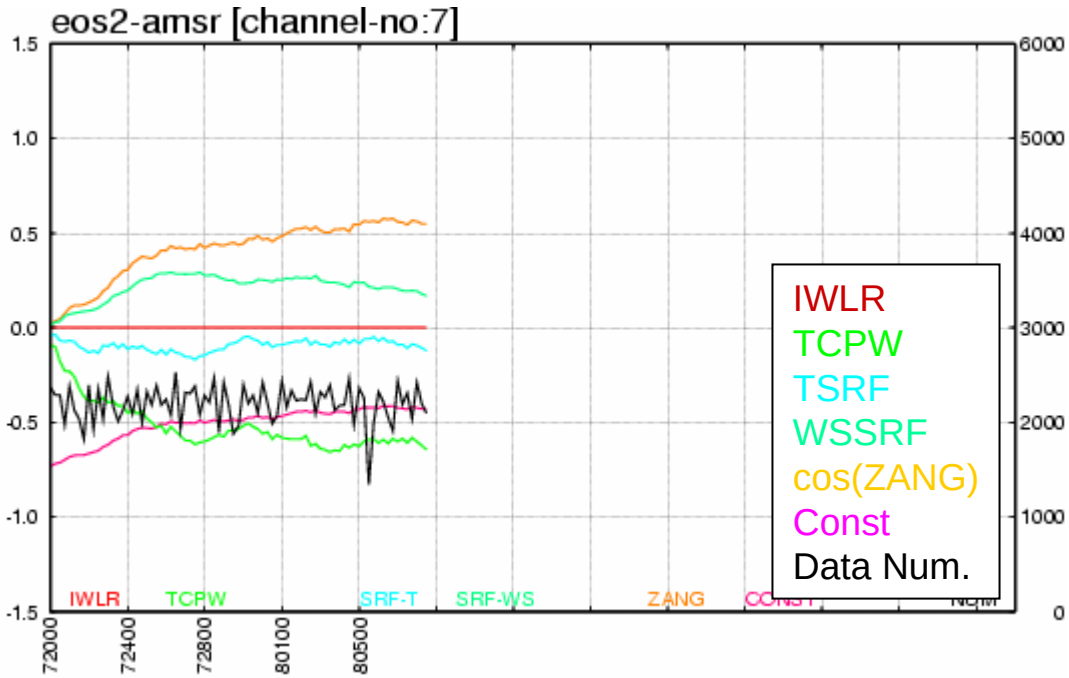
- We are currently doing the new OSE
  - New Bias Correction Method (Variational Bias Correction)
  - New Thinning Method

Current Development

- Employment of Variational Bias Correction
  - for All T_B data (AMSU-A/B, MWRs)
  - Predictors
    - Integrated Weighted Lapse Rate (for AMSU-A)
    - Total Column Precipitable Water (for the AMSU-B & MWRs)
    - Surface Temperature
    - Surface Wind Speed
    - cos (satellite zenith angle)
    - Constant
- Improving the Data Thinning Method
  - considering the time slot differences

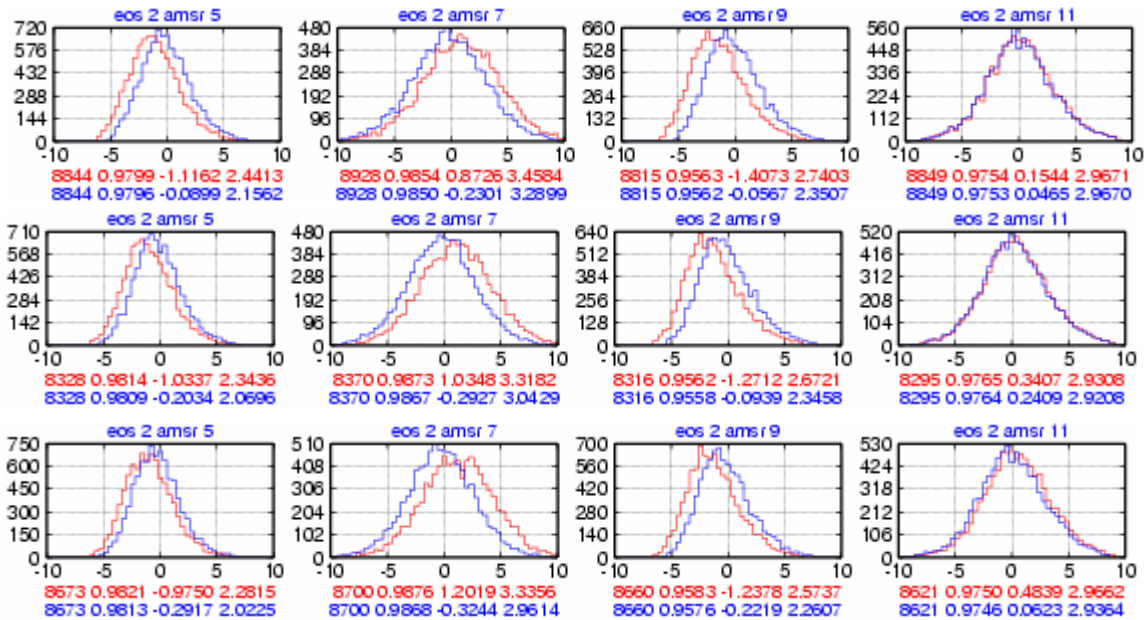
Variational Bias Correction

- The Sequence of the Bias Correction Coefficients
  - It developed rapidly in the 1st 5days,
    and became almost stable after the period in this channel.



Variational Bias Correction

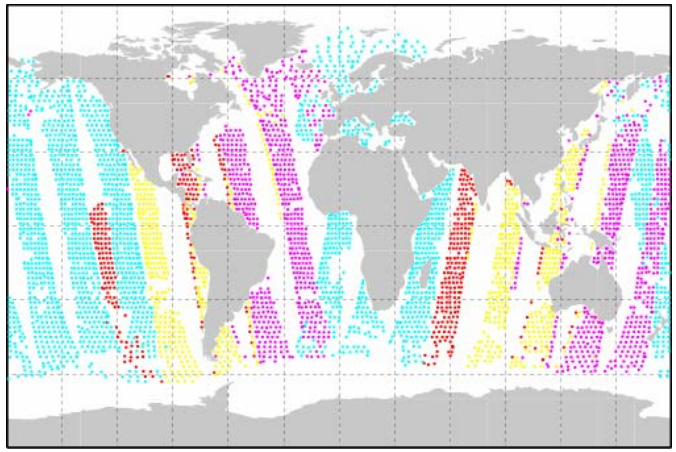
- The sequence of the TB departure histogram
  - Red shows Original data
  - Blue shows Bias Corrected data
    - The RMSE of BC data is reducing gradually.
    - The asymmetry of BC data is also reducing gradually.



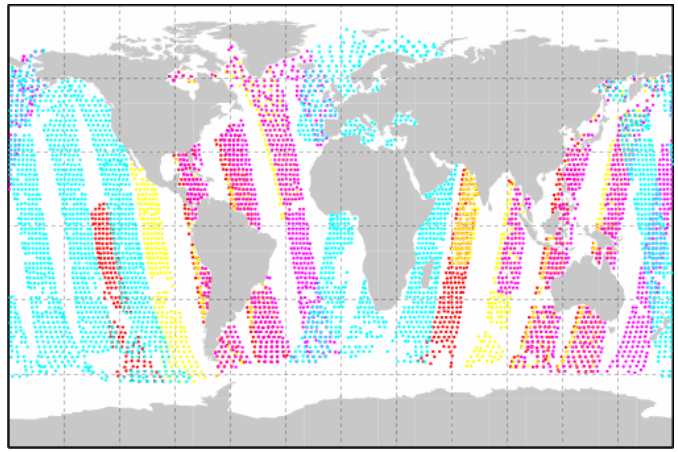
The numbers under the figure shows (N COR ME RMSE)

New Thinning Method

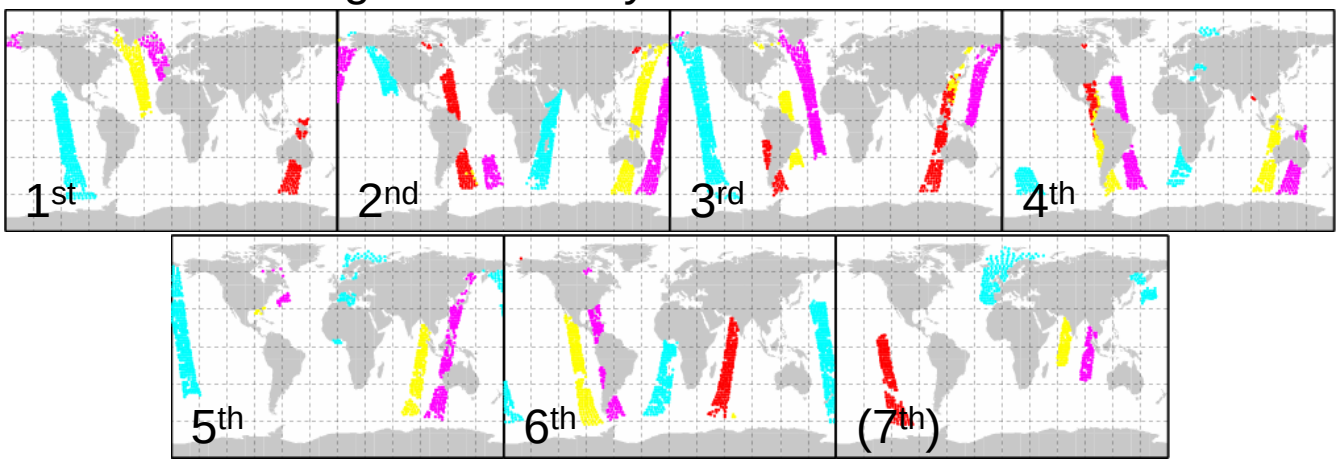
Previous Thinning (N=4337)
(Only Considering Spatial Distribution)



New Thinning (N=6396)
(Considering Assimilation Time Slot)



Dividing to the hourly assimilation time slots.

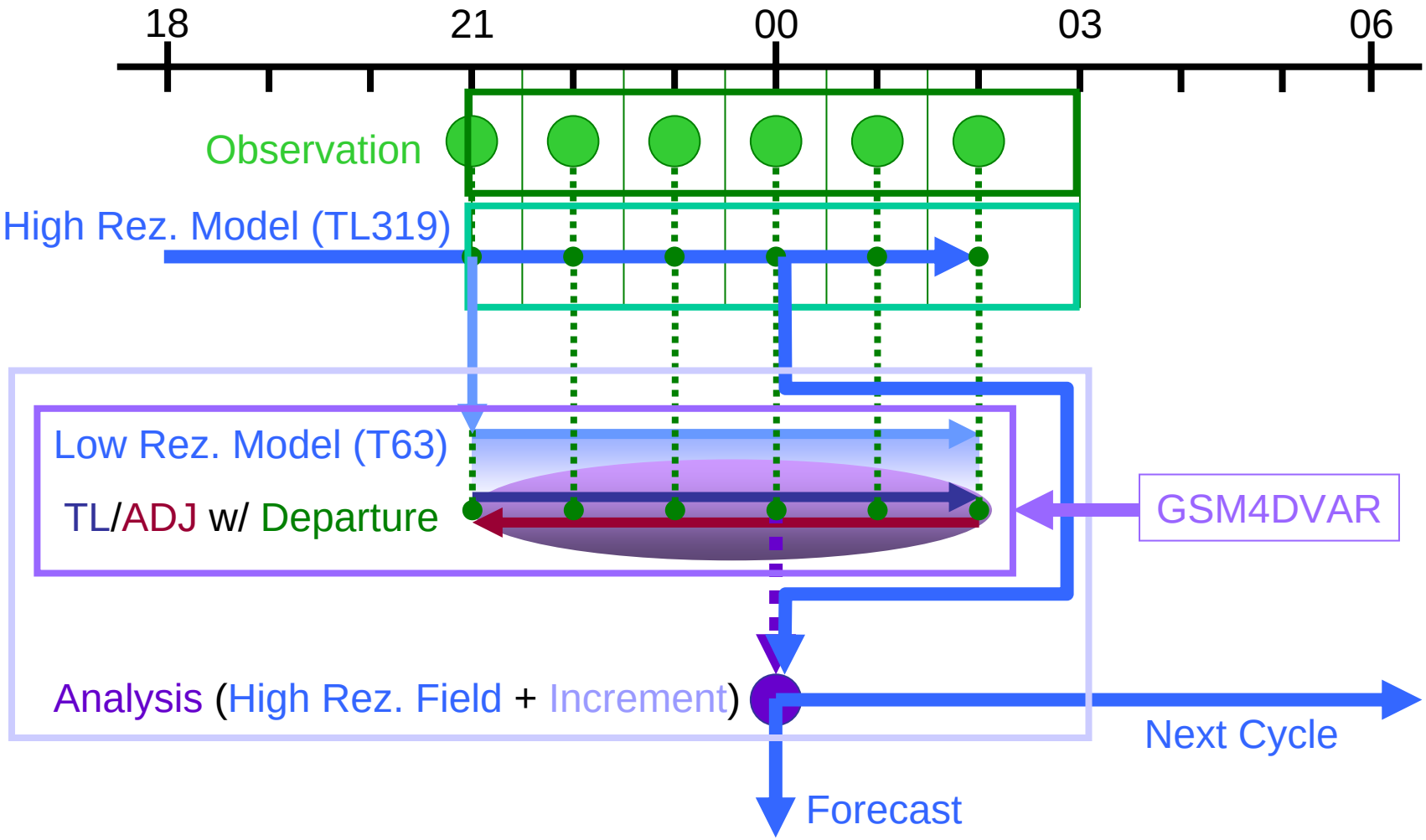


SSM/I(13,14,15), AMSR-E

The positive result is highly expected.

Numerical Prediction Division,
Japan Meteorological Agency

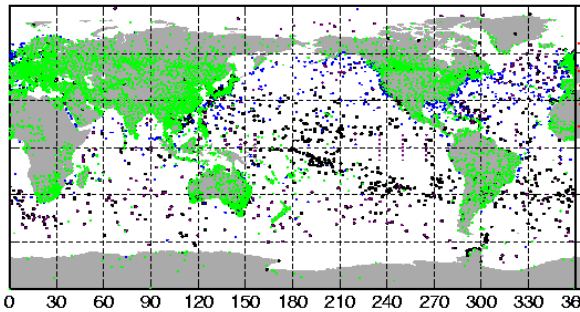
JMA Global Analysis Flow



> Return

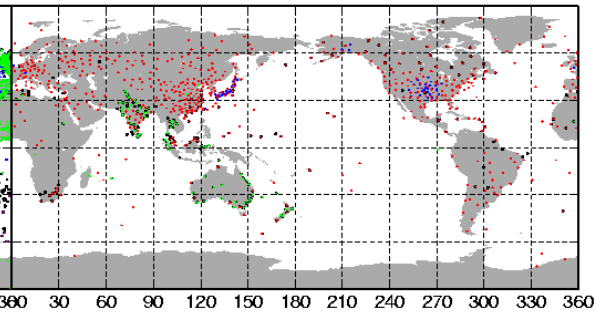
Operationally Used Observations on GSM

SURFACE OBSERVATIONS



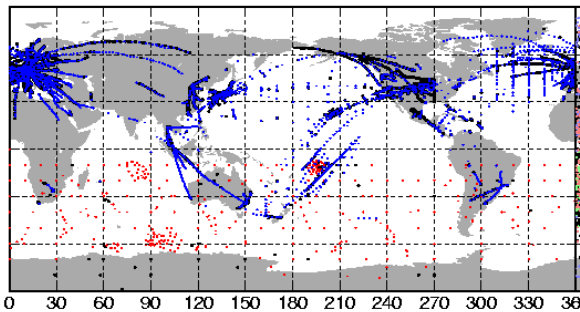
SYNOP METAR SHIP BUOY

UPPER OBSERVATIONS



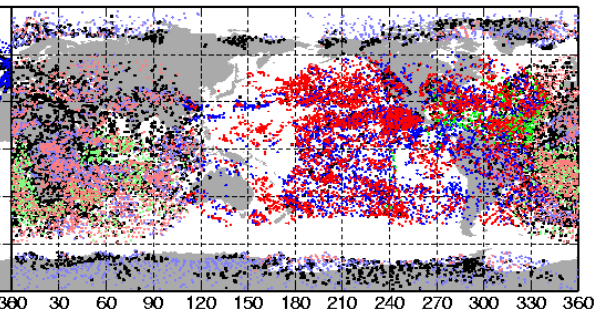
TEMP PILOT WIND PROFILER

AVIATION / BOGUS



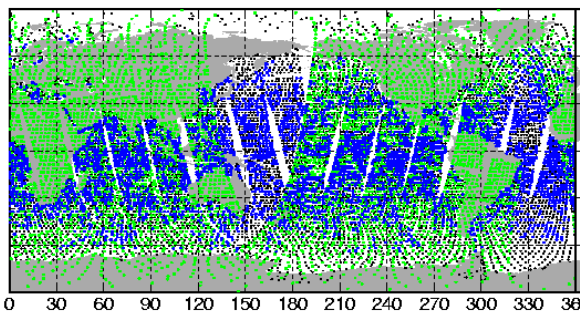
ACARS BOGUS

ATMOSPHERIC MOTION VECTOR



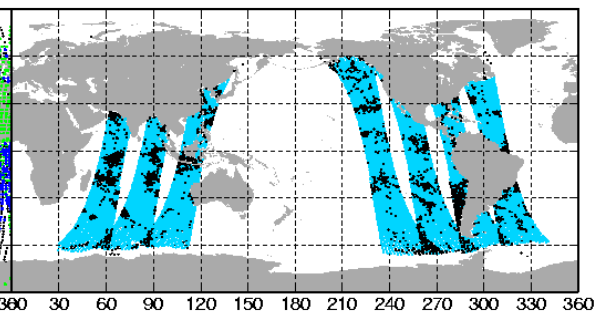
IR VS WV NO_USE

NOAA



AMSU-A AMSU-B NO_USE

SCAT WIND

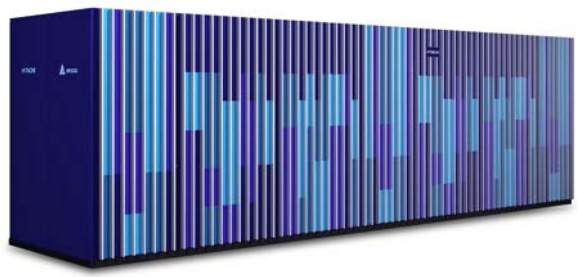


SCAT NO_USE

> Return

Upgrade of the HPC system

- Installing the New HPC system currently
  - Current system: NAPS7 (2001.3-)
    - HITACHI SR8000E1
    - 8CPU (8GByte) x 80 NODE
    - 768GFlops
  - Next system：NAPS8 (2006.3-)
    - HITACHI SR11000J1
    - 16CPU (64GByte) x 210 NODE
    - 27.5TFlops (~35.8 times as NAPS7)
    - Including Meteorological Satellite Center system



http://www.hitachi.co.jp/Prod/comp/hpc/SR/11ktop.html

  - NWP system Upgrade Plan
    - Current: GSM:TL319(60km)L40/12hrly, MSM:10kmL40/06hrly
      - » GA: T63, MA:20km (hydro-static)
    - Next: GSM:TL959(20km)L60/06hrly, MSM:05kmL50/03hrly
      - » GA: T106⇒TL319 , MA:10km (non-hydro-static)